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Effect of working side interferences on mandibular movement in bruxers and non-bruxers

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SUMMARY **The effect of working interference on 13 bruxers and 14 non-bruxers was studied by applying a metal overlay on the buccal cusps of the adjacent upper premolar and molar. The pattern and velocity of cyclic movement during gum chewing before and after overlay insertion were observed. EMG of the temporalis and masseter muscles was recorded bilaterally during the chewing movement. It was found that after insertion, one of the non-bruxers complained of pain in the muscles, while such a complaint was not found in bruxers. Bruxing habit was reported to be less or eliminated in 44% of the bruxers, but no non-bruxers became bruxers. The closing velocity was more often decreased immediately after overlay insertion, and the closing path near the occlusal phase was significantly narrower, with patterns of over-extension and avoidance before reaching the occlusal phase. The delayed effects were a more vertically oriented chewing cycle without over-extended closing movement, and an unretarded chewing velocity. It was concluded that within the experimental period a working side interference was tolerable in most of the subjects studied with or without a bruxing habit.**

Introduction

While the importance of dental occlusion on the occurrence of temporomandibular disorders (TMD) has been debated (De Boever, 1979; Krogh-Poulson, 1980; Pullinger, Seligman & Solberg, 1988), emotional factors such as anxiety and stress have been emphasized as main factors related to muscle hyperactivity, which in turn caused muscle spasm and pain-dysfunction of the muscles and joints. Occlusal alteration, if present, is a result, not a cause of TMD (Laskin, 1969; Yemm, 1971; Laskin & Block, 1986). Although the occlusal factor is no longer as important as when TM joint compression was thought to result from the loss of posterior teeth (Goodfriend, 1933; Costen, 1934), it can be a triggering factor or a sustaining factor for the pain and dysfunction of the muscles and joints (Weinberg, 1979; Ramfjord & Ash, 1983).

Among the types of occlusal alterations that have been considered as contributing factors of TMD, centric prematurity is the one most often discussed (Ramfjord, 1961; Ramfjord & Ash, 1983) while the next is a balancing interference (Perry, 1957; Schaerer, Stallard & Zander, 1967; Shore, 1976; Ramfjord & Ash, 1983; Magnusson & Enbom, 1984). Both centric and balancing interferences are related to bruxism or parafunctional jaw movement (Ramfjord, 1961; Posselt, 1971; Krogh-Poulson, 1980; Rugh, Barghi & Drago, 1984) and have a strong impact on the development of muscle fatigue and pain.

There have been relatively few studies concerning the effect of working side interferences on the masticatory system. Ramfjord & Ash (1983) stated that working side interferences seldom trigger abnormal muscle activity unless the subject has a bruxing habit. They are not as important as centric and balancing interferences on the function and health of the masticatory system. However, this type of interference is often seen, especially when a group function type of occlusion is provided with dental restorations.

Hannam *et al.* (1981) applied acrylic working interferences on posterior teeth of normal subjects and found

an altered chewing pattern and an inconsistent change of muscle activity and jaw displacement. No harmful influence from the addition of working side interferences was found. However, the study was concerned with the immediate effect only. Shiau & Ash (1989) used a metal overlay as a working side interference on normal subjects and found that 14% of non-bruxers complained of pain on the second day. They also found an altered chewing pattern, reduced closing velocity, and premature contraction of the closing muscles. There could be adaptation to all of the altered patterns in one day. However, it is unknown if the working side interferences have been applied on bruxers who have more vigorous tooth contact.

The purpose of the present study was to apply working side interferences on both bruxers and non-bruxers and to observe and compare their immediate and delayed responses.

Materials and methods

Subjects

Fourteen non-bruxers (6 males and 8 females) and 13 bruxers (9 males and 4 females) were examined in this study. All were students and staff of the School of Dentistry, National Taiwan University and its dental clinic. Their ages ranged from 18–31 years. All the bruxers had reports from their roommates, spouses or family that they often made grinding noises at night. Their dentition also showed non-functional wear facets that appeared shiny and well demarcated. Three of them had occasional muscle stiffness in the morning, but none had pain in their jaw muscles or TM joints. The non-bruxers did not have a bruxing report and their teeth did not show attrition facets with sharp borders. Both of the groups had complete dentitions, nearly intact dental occlusion, and asymptomatic masticatory muscles and TMJ.

Procedures

A metal overlay was made on the stone cast of the upper second premolar and first molar on the habitual chewing side. It was approximately 1·5 mm in thickness at the cusp tip area and excluded the other teeth during lateral excursion without causing a centric prematurity. The overlay was adjusted at the chair side and prepared to be seated with an acid etch resin cement*.

Session W0

Before the working side interference was applied, the subject was seated upright in a dental chair with the head supported. Paired surface electrodes (Ag/AgCl) were attached over the centre of the belly of the anterior temporalis, masseter and anterior digastric muscles. Muscle activity was amplified in a 12-channel EMG†. Jaw motion was recorded using a light-emitting diode (LED) system‡. The LED was positioned in a clutch luted on the labial surface of the lower incisors. The muscle activity and the jaw motion in two dimensions were recorded with an FM tape recorder§ and replayed on an X-Y plotter.

The subject was asked to perform the following movements: centric contact, right and left lateral excursion, and opening from right and left extreme positions. A piece of gum was then chewed and softened before recording of chewing movement was started.

Session W1

Immediately after session W1, the overlay was luted on the chosen teeth and the contact condition was checked. The same recording procedure as used in W0 was then performed without changing the electrodes and LED placement.

Sessions W2, W3 and W4

These sessions were performed 1 day, 1 week and 1 month after overlay insertion. The electrodes were replaced so that they were at the centre of each muscle belly. The same clutch and LED were re-used during these sessions.

Measurement of chewing movement and EMG during gum chewing before and after overlay insertion was made on 10 consecutive chewing cycles started from cycle no. 5 to cycle no. 14. As seen in Fig. 1, the angle formed in the frontal plane between the closing path and the vertical axis was considered the angle of closing path (∠AC). The closing path measured was that within the range of 3 mm of vertical separation from the centric occlusion phase. The angle formed between the axis of

* Panavia EX, Kuraray Co. Ltd., Okayama, Japan.
† EP12 Polyanalyser, OTE Biomedica, Firenze, Italy.
‡ Saphon Visi-Trainer CIII, Tokyo Shizaisha Co., Tokyo, Japan.
§ 3968 A Instrumentation Recorder, Hewlett Packard, Palo Alto, U.S.A.

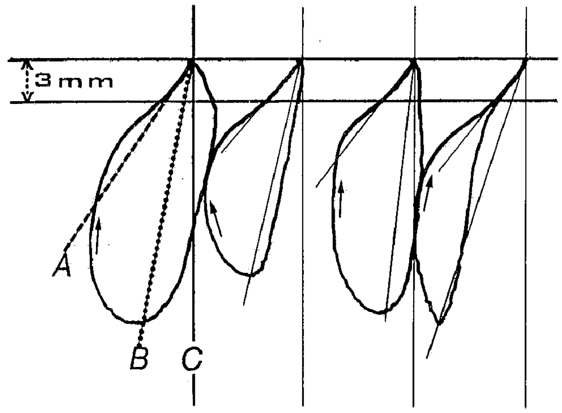

Fig. 1. Measurement of the angle of closing path and the chewing axis. ∠AC = angle of closing path; ∠BC = angle of chewing cycle axis.

the chewing cycle and the vertical axis was considered the angle of chewing axis (∠BC). The differences in EMG and jaw motion among five sessions and between the bruxers and non-bruxers were analysed and compared intra- and interindividually. ANOVA and the Student's t-test were applied for data analysis. Statistically significant differences were those with $P<0{\cdot}05$.

Results

The insertion of the overlay immediately changed the pattern of border movements. Six of the 14 non-bruxers (42·9%) had an increased border area and eight (57·1%) had a decreased border area. In bruxers, eight (61·6%) had an increased border area and five (38·4%) had a decreased area. In addition, one of the non-bruxers (7·1%) complained of pain in his masseter muscles at session W2, while none of the bruxers had a pain complaint throughout the observation period. The overlay was removed from the painful subject for ethical reasons and the pain disappeared in 3 days. At session W2, two non-bruxers (14·3%) and four bruxers (30·8%) found that the overlay was detached. The experiment in these six subjects was discontinued. In the remaining nine bruxers, four of them (44·4%) reported less frequent or no bruxing during the experimental period, and none of them reported more bruxing. In the non-bruxer group, none reported bruxing after insertion of the overlay. Their reports were confirmed by their roommates, spouses or family.

Nine of the 14 non-bruxers showed a narrower closing angle at session W1. As seen in Table 1, the mean ∠AC at W0 was 41·2 ± 13·3 degrees vs. 28·1 ± 14·7 degrees at W1; the difference being significant ($P<0{\cdot}05$). At sessions W2, W3 and W4, ∠AC was about 30°. In bruxers, the mean ∠AC at W0 was 40·2 ± 6·7° and at W1 was 32·0 ± 7·7° ($P<0{\cdot}05$). The closing angle at W2, W3 and W4 was approximatly 30°. The difference between W0 and the other sessions was also significant ($P<0{\cdot}05$). The difference in ∠AC between bruxers and non-bruxers was not significant at any of the sessions.

The axis of chewing cycle in the frontal plane became slightly more vertically oriented at W1 and the sessions thereafter. However, the difference in ∠BC between W0 and the other sessions was not significant statistically ($P>0{\cdot}05$).

Alteration of the chewing pattern not only was found during the closing path near the centric position, but also during the closing path before entering the occlusal table. Four (28·6%) of the non-bruxers and five (38·5%) of the bruxers developed an overextended closing path at W1. The mandible moved more laterally at the begining of the closing movement and remained in the lateral position until meeting the tip of the overlay or even beyond it before sliding back to centric position along the lingual contour of the buccal cusps (Fig. 2). The pattern of the overextended closing path was seen at sessions W1 and W2 in non-bruxers and W1 only in bruxers.

Another type of altered closing path was the pattern of avoidance in which the closing movement was more vertically oriented. The mandibular cusps did not seem to contact the lingual surface of the overlay before reaching centric position (Fig. 2).

The closing velocity during gum chewing at different sessions is shown in Table 2. The average closing velocity

Table 1. Angle of closing path (∠AC) measured at five sessions on bruxers and non-bruxers

	Non-bruxers			Bruxers		
	X̄	s.d.	CV(%)	X̄	s.d.	CV(%)
W0	41·2	13·3	32·3	40·2	15·6	38·8
W1	28·1*	14·7	52·3	32·0*	14·6	45·6
W2	32·1*	15·3	47·7	32·0*	12·8	40·1
W3	30·8*	13·7	44·5	26·8*	8·9	33·1
W4	30·5*	15·9	52·1	29·4*	9·3	31·6

CV: coefficient of variance; *: significant difference ($P<0{\cdot}05$) between W0 and other sessions; W0 to W4: sessions, before and after overlay insertion.

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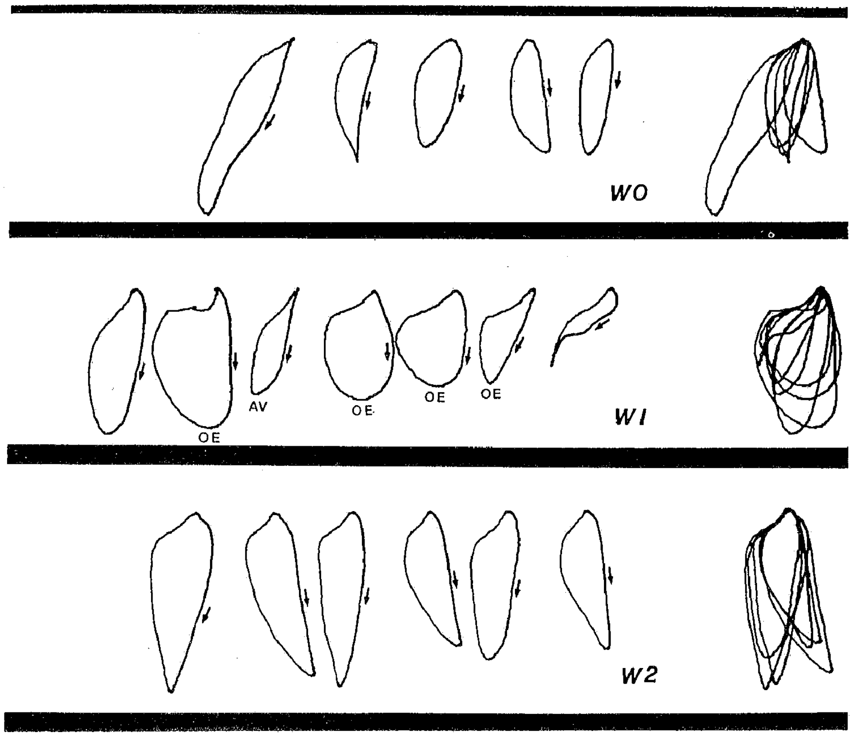

Fig. 2. Patterns of gum chewing before and after overlay insertion. Note the pattern of overextention (OE) and avoidance (AV) at W1 and W2.

of non-bruxers at W0 was not significantly different from that of bruxers (closing velocity: 51·8 ± 18·3 mm/s vs. 45·0 ± 21·7 mm/s; opening velocity: 44·5 ± 12·8 mm/s vs. 45·5 ± 15·1 mm/s). Because of the wide variety in the chewing velocity between individuals it was difficult to find a significant change of either opening or closing velocity at W1 or sessions thereafter. However, if observed individually, as seen in Fig. 3, there were nine non-bruxers (64·3%) and seven bruxers (53·8%) who had the closing velocity decreased at W1. At W2, 75% of the non-bruxers and 72% of bruxers had the closing velocity increased up to the level of W0 or even higher. At sessions thereafter, the closing velocity generally maintained a higher than W0 level, with less fluctuation than from W0 to W2. Opening velocity on average was slower than closing velocity. At W1, 35·7% of non-bruxers and 38·5% of bruxers showed decreased opening velocity. At session W2, 66·6% of non-bruxers and 50·0% of bruxers increased their opening velocity. Again at sessions W3 and W4, the opening-velocity became more stable in both non-bruxers and bruxers.

The contraction period of the temporalis muscle during gum chewing was about 250 ms in non-bruxers and 262 ms in bruxers at session W0. Immediately after overlay insertion, it became significantly longer (285 ms in non-bruxers and 290 ms in bruxers, $P<0{\cdot}05$). At sessions W2, W3 and W4, the average contraction period returned to the level of W0 (Table 3). Duration of mas-

		W0		W1		W2		W3		W4	
		O	C	O	C	O	C	O	C	O	C
Non-bruxer	$\bar{X}$	44·5	51·8	51·8	49·1	57·3	58·7	59·1	65·7	57·7	63·6
	s.d.	12·8	18·3	15·4	17·9	12·8	12·9	12·5	14·5	12·9	16·6
Bruxer	$\bar{X}$	45·5	45·0	51·2	40·8	57·5	49·0	52·6	52·5	52·5	58·0
	s.d.	15·1	21·7	13·0	17·7	18·2	28·6	5·0	7·2	8·9	15·6

O: opening velocity; C: closing velocity; W0 to W4: sessions, before and after overlay insertion.

Table 2. Opening and closing velocity during gum chewing in bruxers and non-bruxers at different sessions (in mm/s)

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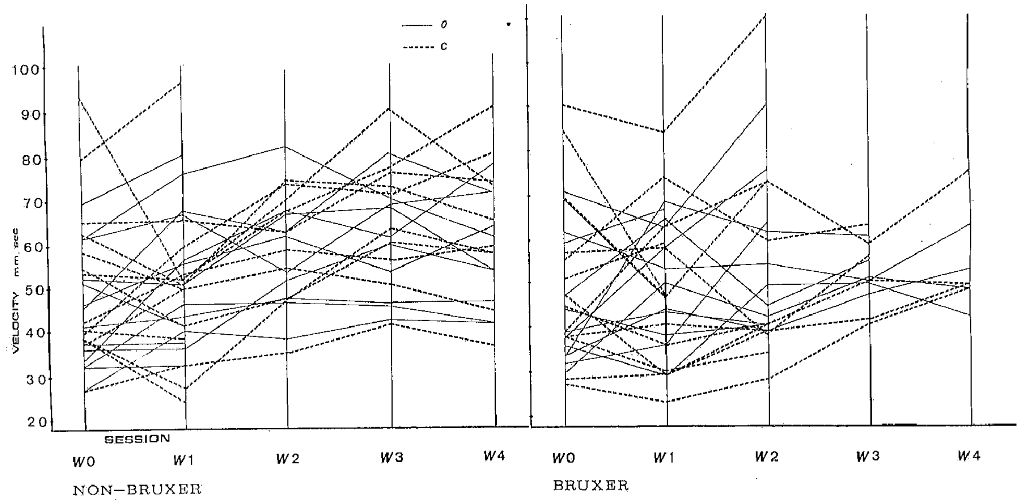

Fig. 3. Velocity change of opening and closing movement during gum chewing at five sessions. O = opening velocity; C = Closing velocity.

seter muscle activity was generally slightly shorter than that of the temporalis, but its change with sessions was about the same. As seen in Fig. 4, the prolonged contraction period basically corresponded to the appearance of an overextended closing movement. No difference in the contraction period was seen between non-bruxers and bruxers.

Discussion

The velocity of jaw closing movement decreased immediately after overlay insertion in most of the non-bruxers and bruxers, suggesting an awareness and avoidance of the working side contact on the metal overlay. Two types of avoidance were found in this study. The first type appears to be a normal lateral movement during the early part of the closing path and a restricted movement later near occlusion. The more mesially or vertically oriented chewing cycle axis was another type of avoidance, which represents an adjustment of the cyclic movement after contacting the overlay. Hannam *et al.* (1981) also proposed the concept of avoidance related to the presence of a working side interference. In addition to the pattern of avoidance, there is a more characteristic response to the working side interference involving an overextended closing path. It seems that the mandible moved more laterally to touch and detect the existence of the prematurity or to try to grind it away. The higher incidence of overlay detachment in bruxers also suggested more frequent and stronger grinding on the overlay in bruxers who had more often tooth contact both in the daytime and at night.

Table 3. Contraction period of jaw closing muscles during gum chewing in non-bruxers and bruxers at sessions before and after overlay insertion (in ms)

	W0	W1	W2	W3	W4
	$\bar{X}$ s.d.	$\bar{X}$ s.d.	$\bar{X}$ s.d.	$\bar{X}$ s.d.	$\bar{X}$ s.d.
Non-bruxer					
Temporalis	250 ± 48	285 ± 86*	265 ± 48	244 ± 50	258 ± 65
Masseter	237 ± 68	270 ± 78*	243 ± 96	226 ± 54	238 ± 90
Bruxer					
Temporalis	262 ± 52	290 ± 75*	260 ± 62	255 ± 54	248 ± 72
Masseter	228 ± 74	289 ± 68*	236 ± 61	240 ± 45	233 ± 49

*: significant difference ($P < 0.05$) between W0 and W1; W0 to W4: session, before and after overlay insertion.

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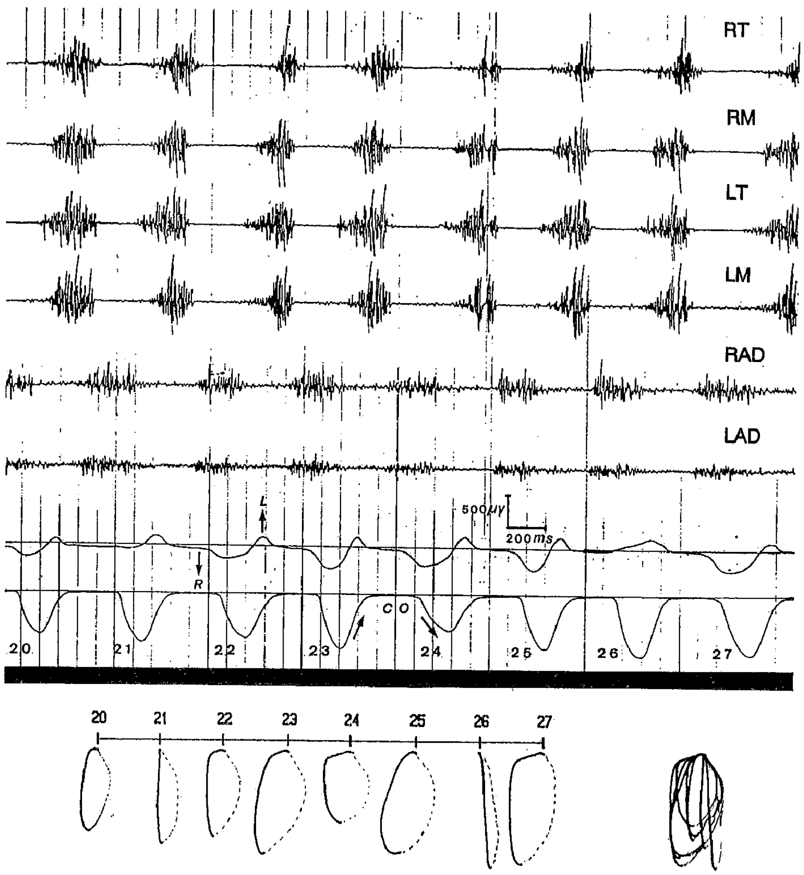

Fig. 4. Duration of muscle contraction during right side gum chewing of a non-bruxer at session W1. RT = right temporalis; RM = right masseter; LT = left temporalis; LM = left masseter; RAD = right anterior digastric; LAD = left anterior digastric. Horizontal scale 200 ms, vertical scale 500 μv. The last two tracks are the jaw movement on X (right and left) and Y (up and down) dimensions. The corresponding number of chewing cycles is shown at the bottom. Solid line: closing path; shaded line: opening path.

It is not easy to judge if the reports of decreasing bruxing habit at night in some bruxers in this study is an outcome of overlay application. Rugh *et al.* (1984) applied a metal crown with deflective contact on a molar of bruxers and found a decrease of muscle activity at night. They concluded that the occlusal factor did not elicit nocturnal bruxing even in subjects with a bruxing history. Furthermore, it had been suggested that addition of canine guidance on a group function occlusion could immediately reduce the activity of the jaw closing muscles (Manns, Chan & Miralles, 1987). The bruxers with a buccal overlay probably can also reduce their muscle tension and do less bruxing. However, because of the lack of a more objective way to monitor the bruxing activity at night, and the evidence of a high overlay detachment rate in the bruxer group, it is difficult to draw a similar conclusion in this paper. The verbal report of less bruxing from the bruxers might be based on a less evident bruxing noise normally noticed by their roommates, but not necessarily on less bruxing.

Subjects who had a narrow closing angle without earlier contraction of jaw closing muscles probably did not make any gliding contact on the overlay or buccal cusps of the upper teeth during jaw closure. The neuromuscular system tried to avoid the contact of the overlay by limiting the lateral movement of the jaw during closure. The change of the apperance of an overextended lateral closing movement depends upon the subject's response to the presence of the working side interference. It seems that the bruxers had slightly better awareness and a stronger response.

At session W2, both non-bruxers and bruxers resumed their closing velocity to the level of W0 and the incidence of overextended closing movement was much reduced. This might suggest that adaptation to the working side interference occurred within 1 day. The insignificant change of ∠BC and the smaller ∠AC at sessions W1 and thereafter suggested that they adapted to the new situation by limiting the lateral extension of the closing movement in 1 day or less.

The velocity change in both the non-bruxers and

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bruxers after session W2 was not as significant as was seen at W1. The velocity of jaw movement, especially during closure, increased fairly consistently and became even faster than before the insertion of the overlay. This phenomenon could be the result of repeated practice when the subjects became familiar with the overlay and the LED tracking system. It had been shown that the border movement of the jaw traced with the LED system can become broadened after visual feedback training and practice (Wang & Shiau, 1987). The increased opening and closing velocity at sessions W2, W3 and W4 might also suggest the effect of practice and accommodation. We believe that the addition of the overlay did have a strong impact on chewing velocity making it significantly slower at session W1 rather than faster, as would be expected due to practice.

According to the findings of this study on chewing velocity, chewing cycle pattern and symptoms, it is difficult to suggest that a working side interference often causes substantial change in the masticatory system even when the interference was applied on bruxers and stayed for 1 month. From the findings of this report and previous studies (Hannam *et al.*, 1981; Shiau & Ash, 1989), we believe that a working interference is not an important factor that can be related to the TMD symptoms. However, the results of this study could not confirm the findings and suggestion of Rugh *et al.* (1984) that an occlusal interference could reduce the bruxing activity of bruxers. The higher overlay detachment rate in bruxers in this study suggests more frequent or more powerful jaw movement at night in some bruxers, although their verbal report indicated no bruxing.

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